

LA-UR-20-23702

Approved for public release; distribution is unlimited.

Title: Next steps in our hydro simulations core and surface, g-modes and p-modes

Author(s): Edelmann, Philipp Valentin Ferdinand

Intended for: talk

Issued: 2020-05-18

Disclaimer:

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by Triad National Security, LLC for the National Nuclear Security Administration of U.S. Department of Energy under contract 89233218CNA000001. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

NEXT STEPS IN OUR HYDRO SIMULATIONS

CORE AND SURFACE, G-MODES AND P-MODES

Philipp Edelmann



FULLY COMPRESSIBLE SIMULATIONS

Astronomy & Astrophysics manuscript no. igw
May 5, 2020

©ESO 2020

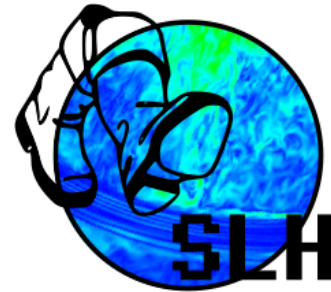
Fully compressible simulations of waves and core convection in main-sequence stars

L. Horst¹, P. V. F. Edelmann^{2,3}, R. Andr  ssy¹, F. K. R  pke^{1,4}, D. M. Bowman⁵, C. Aerts^{5,6,7}, and R. P. Ratnasingam²

Just resubmitted...

SEVEN-LEAGUE HYDRO CODE

- fully compressible Euler equations in 1-, 2-, 3-D
- finite-volume scheme: stable without setting an explicit viscosity
- Cartesian, spherical, or other geometries
- colocated grid (all variables defined at cell centers)
- explicit or implicit time integration
- more detailed microphysics (EoS similar to MESA)



Pro:

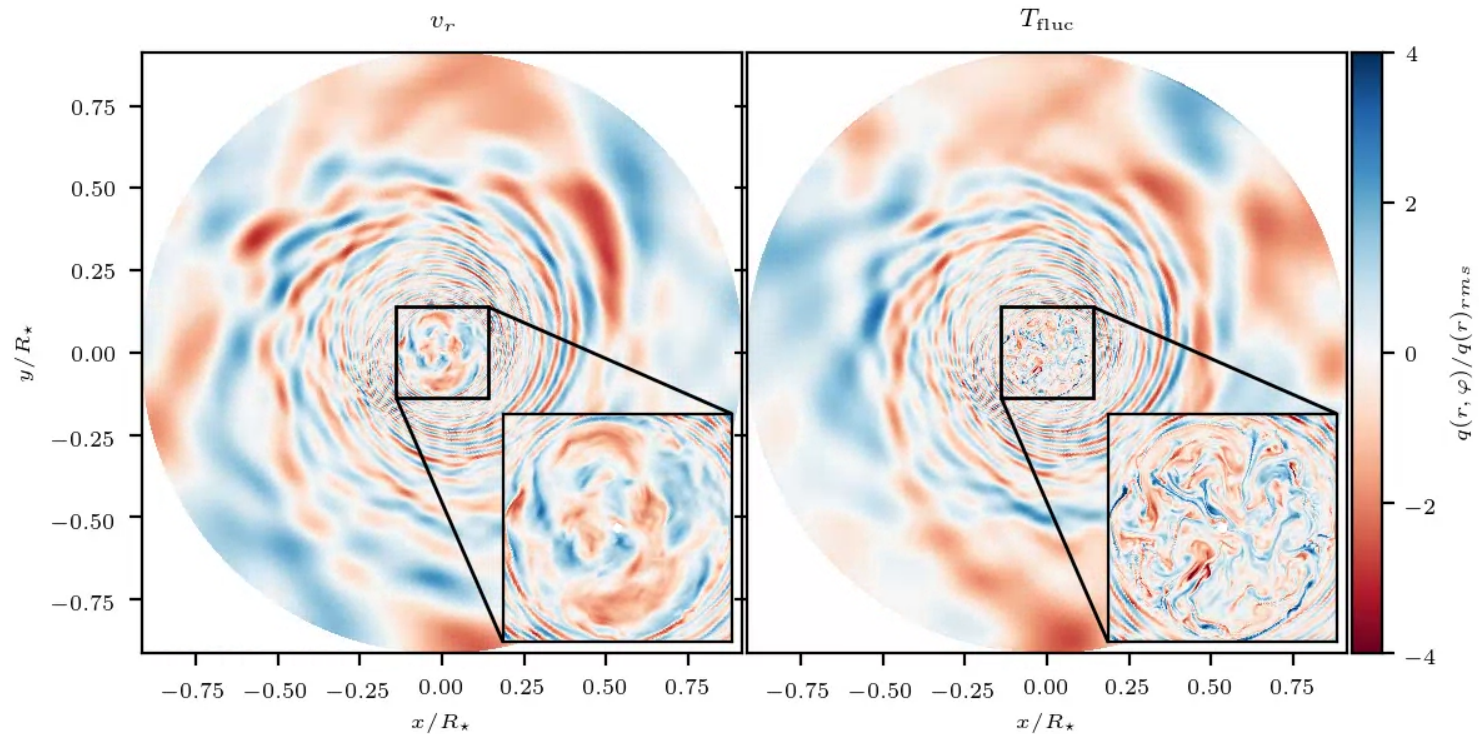
- can simulate sound waves
- exactly follows physical conservation laws
- no explicit viscosity needed
- EoS similar to MESA

Con:

- Spherical geometry cut at the pole
- exact amount of numerical viscosity undetermined
- computationally expensive

2D RESULTS FROM HORST+ (2020)

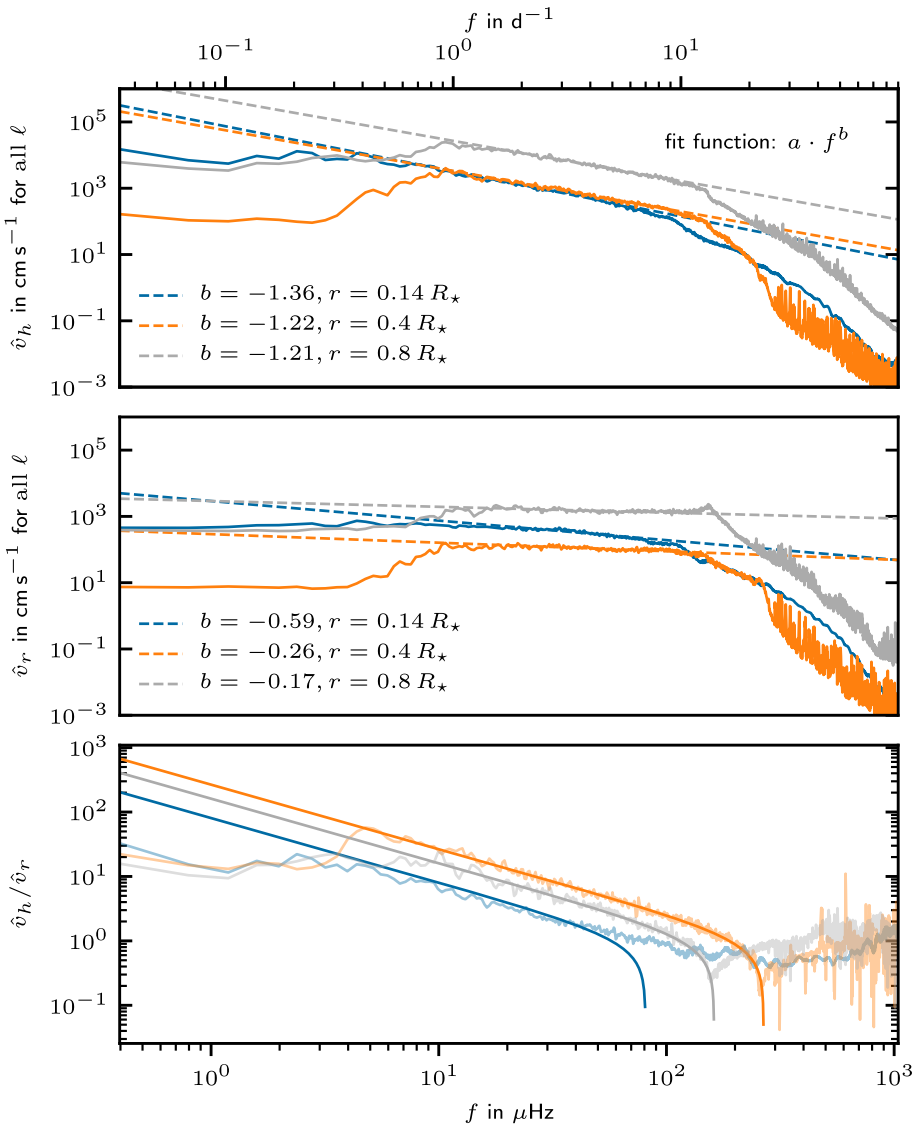
$t = 332.80$ hour



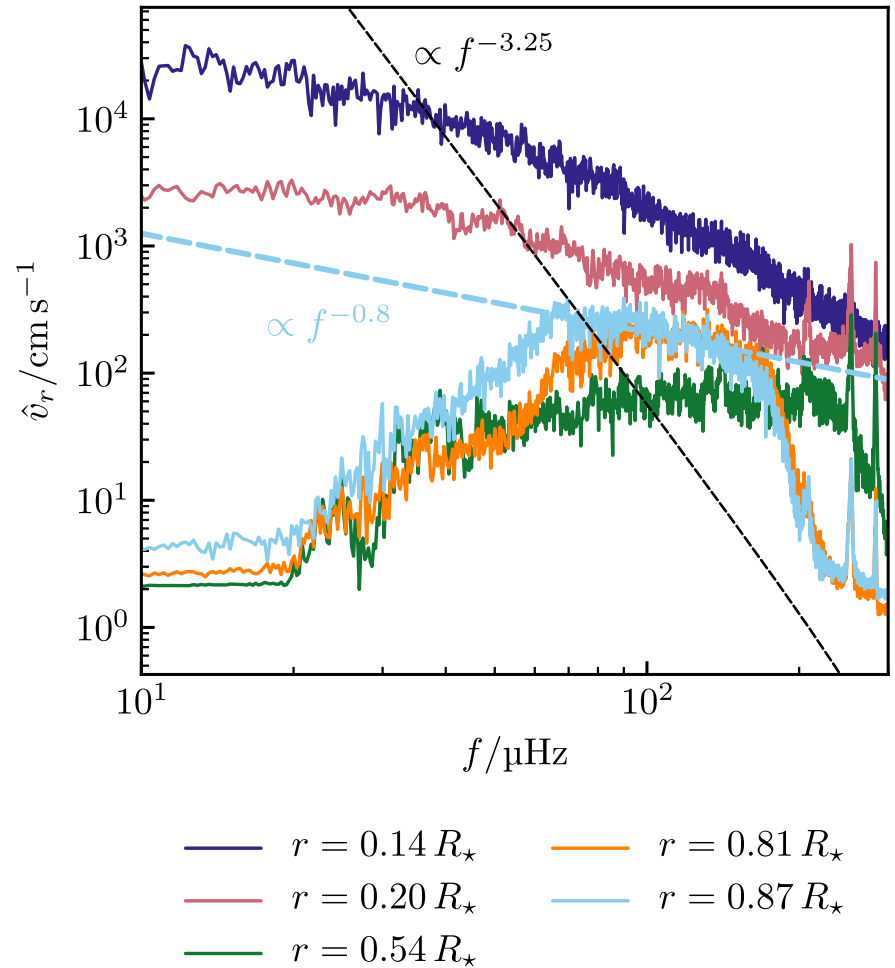
▶ 0:20 / 2:15



VELOCITY SPECTRA

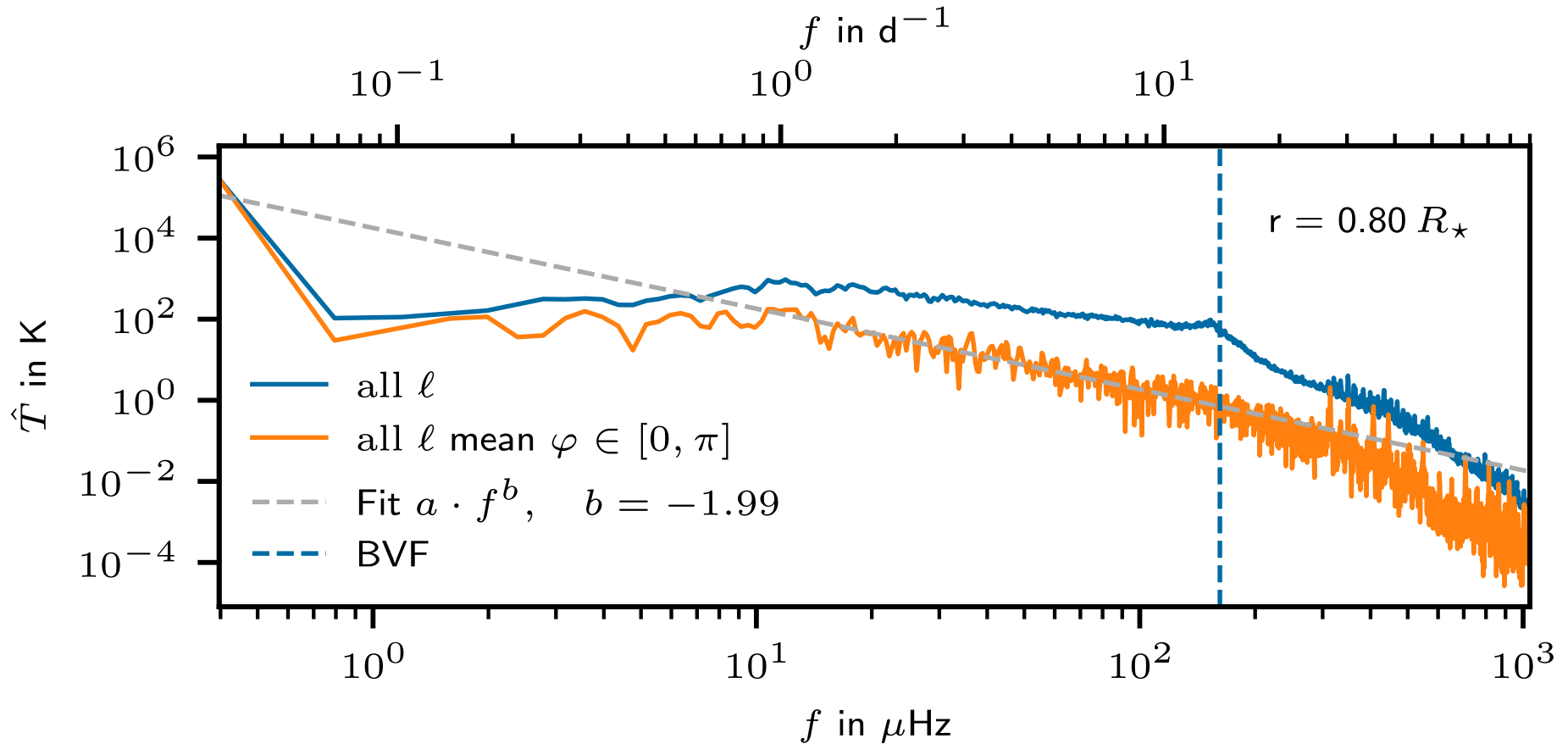


radial velocity from Edelmann+ (2019)

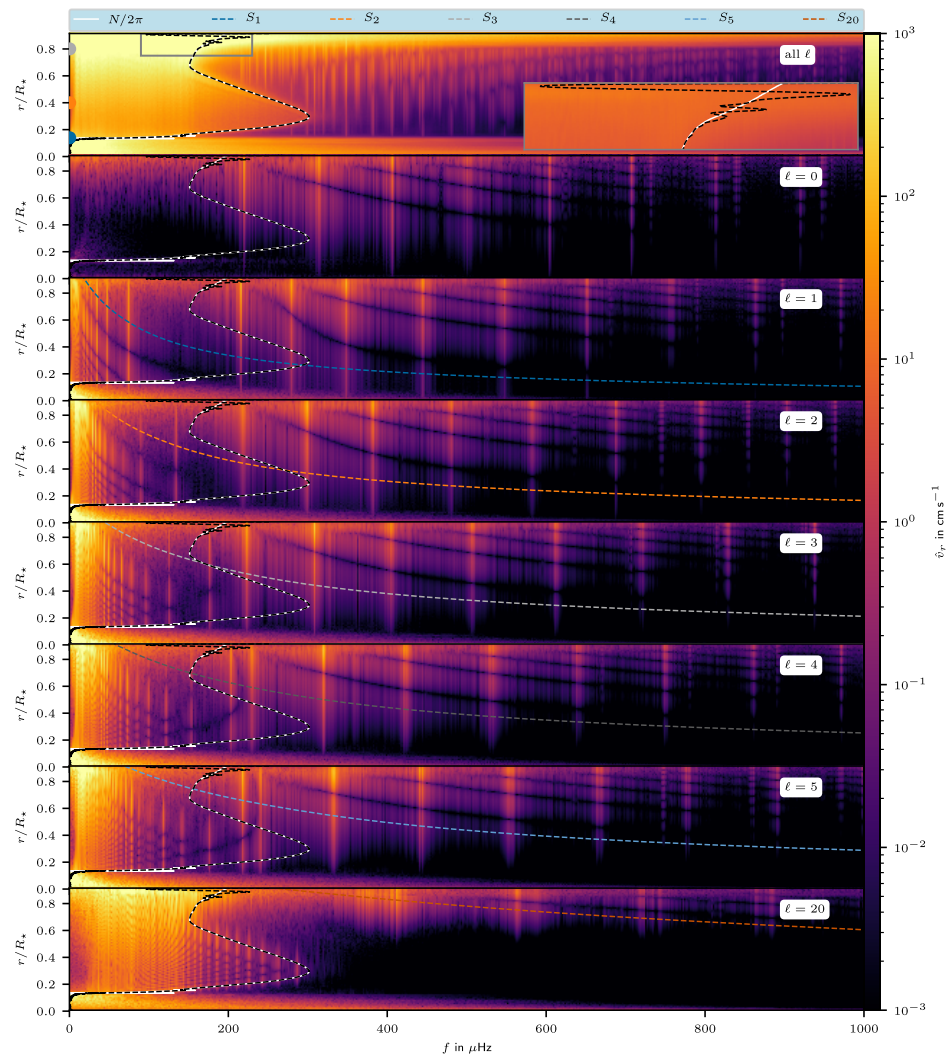


TEMPERATURE

averaged over semicircle to pretend observation
Suggested discussion: How can we do this better?



P-MODES AND G-MODES



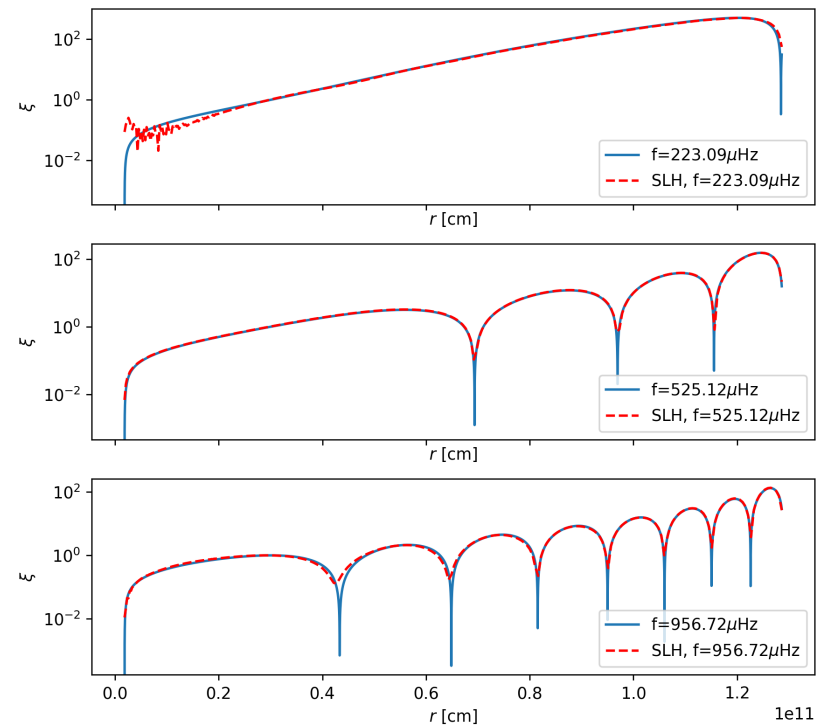
INITIAL 3D WORK

work by Leo & Robert

- initial 3D simulations at $\frac{1}{4}$ the 2D resolution: $280 \times 90 \times 180$
- theoretical comparison with a radial p-mode as a test

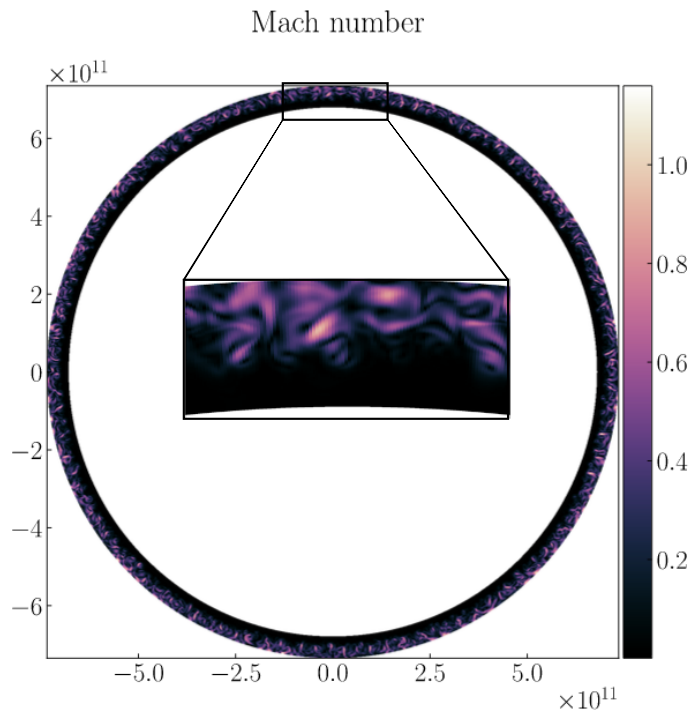
Why not just use GYRE?

- GYRE does not support our hard-wall BCs.
- We did not manage to turn on the Cowling approximation in GYRE. We need it, because we use a static gravitational field in SLH.



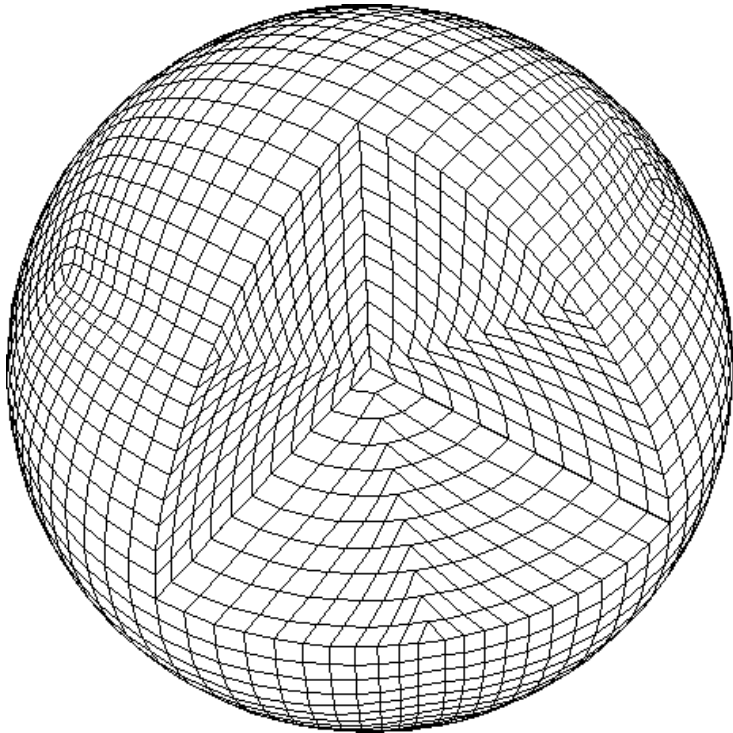
SURFACE CONVECTION SIMULATIONS

state three years ago

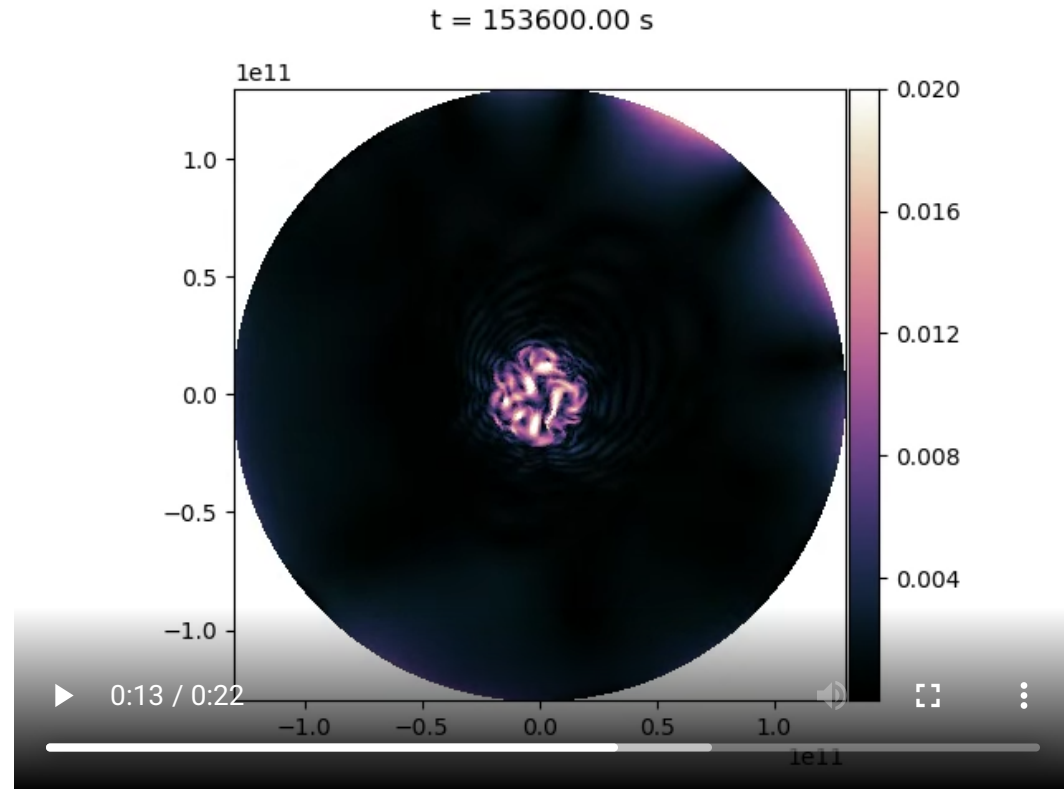


- transonic convection
- SLH was lacking operator splitting to treat radiative diffusion implicitly and hydro explicitly
- This is implemented now!

SIMULATIONS WITHOUT A CUT-OUT CORE



cubed-sphere grid

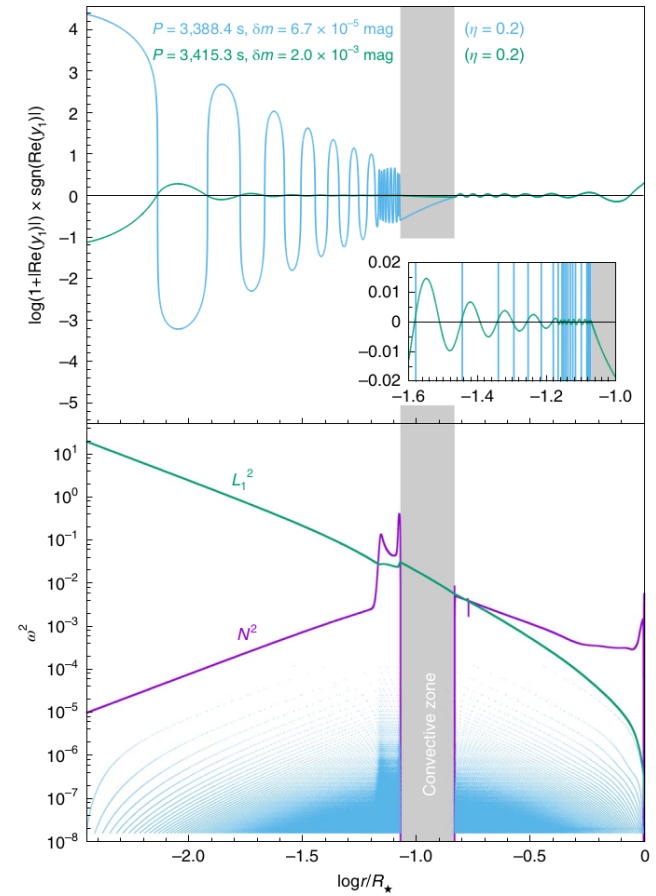


preliminary test by Leo

ASTEROSEISMIC SIGNATURES OF THE HELIUM-CORE FLASH

work by Johann Higl (postdoc@HITS)

- Convective He-burning shell during Sub-He-Flash of SdB star
- SLH simulations (likely 2D for now)
- from CZ up to ~85% of star's radius (95% might also be possible depending on resources)
- stiff convective boundary



Bertolami+ (2020)